DISPERSION RELATIONS IN $\bar{K}N - \pi Y$ COUPLED CHANNEL ANALYSES

PAOLO M. GENSINI

Dip. Fisica, Università, and Sez. I.N.F.N., Perugia, Italy

RAFAEL HURTADO

Dip. Fisica, Università, and Sez. I.N.F.N., Perugia, Italy, and C.I.F., Bogotá, Colombia

GALILEO VIOLINI

Dip. Fisica, Università della Calabria, and Gruppo Coll. I.N.F.N., Cosenza, Italy, and U.N.E.S.C.O., Santiago, Chile

Rapidly convergent, unsubtracted dispersion relations have been used to test coupled–channel analyses of low–energy $S = -1$ meson–baryon channels.

Processes like $\pi\Lambda$ and $\pi\Sigma$ elastic scattering, or $\pi\Lambda \to \pi\Sigma$, are not accessible to experiment: their amplitudes could only be accessed as a byproduct of the coupled–channel **K**–matrix formalism employed to analyse $\bar{K}N$ interactions. Our purpose is to analyse in detail the dispersion relations that can be written for these channels and saturated with a minimum of additional hypotheses, in order to understand whether analyticity constraints, imposed on these channels, combined with the results of suitable experiments at DAΦNE, might improve our knowledge on the $\bar{K}N - \pi Y$ coupled–channel amplitudes. The experiments used to determine the **K**–matrix elements had statistics much lower than those attainable at DAΦNE, and this machine will be able to explore in detail the very-low energy region around the $\bar{K}^0 n$ charge-exchange threshold, where energy–dependent effects due to the $K^- p - \bar{K}^0 n$ mass difference are expected to show up.

We use the low–energy amplitudes obtained in a coupled–channel, **K**–matrix analysis [1] to calculate the $\pi Y \Sigma$ couplings by conventional dispersion relations (D.R.'s) applied to the three $\pi Y \to \pi Y'$ reactions, namely elastic $\pi\Lambda$ and $\pi\Sigma$ scattering and $\pi\Lambda \to \pi\Sigma$. We have chosen amplitudes with the fastest decrease as $\omega \to \infty$: in terms of the invariant amplitudes $A(\omega, t)$, $B(\omega, t)$ and $C(\omega, t)$ (with $C(\omega, t) = A(\omega, t) + \omega B(\omega, t)/[1 - t/(M + M')^2]$ being the amplitude whose imaginary part in the forward direction is given by the optical theorem as $k\sigma_{tot}(k)/4\pi$), we use $B(\omega, 0)/\omega$ for the elastic $\pi\Lambda$ and $\pi\Sigma$ scattering, and $C(\omega, 0)/\omega$ for the inelastic process $\pi\Lambda \to \pi\Sigma$. A and C are dominated by the S–wave, while B by the P–waves: since the

most recent K–matrix analyses are purely S–wave, and the existence of the $\Sigma(1385)$ requires at least inclusion of the P_{13} one as well, a calculation using such parametrizations would be useless for B, whereas for A and C would lead to determine an "effective coupling" for both the Σ and the $\Sigma(1385)$ [2]. Due to the absence of information on the I = 2 $\pi\Sigma$ amplitude, in the elastic $\pi\Sigma$ DR we are forced to use [3] the crossing-even combination of isospin amplitudes $2B_1(s,t,u) - B_0(s,t,u)$, which is the only one free of the I = 2 part both in the s and u channel.

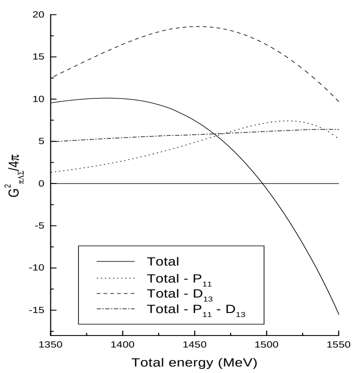

Figure 1. $G^2_{\pi\Lambda\Sigma}/4\pi$ from $\pi\Lambda \to \pi\Lambda$

For the low–energy region there exist two *published* **K**–matrix parametrizations extending down to the $\bar{K}N$ threshold and including S–, P– and D–waves: the second (Gupta, *et al.* [4]) includes also F–waves and is an amalgamation of different analyses, but it does not reproduce the expected structures below the $\bar{K}N$ threshold: this leaves only the first one (the old Kim's parametrization of 1967 [1]) as the only viable choice for such calculations. We have slightly corrected Kim's D–waves in order to describe with correct threshold behaviours the very–low energy region: for the D_{03} wave we have limited ourselves to modify the interaction–radius dependence so as to eliminate a spurious singularity in the unphysical region, replacing $(X^2+k^2)^{-2}$ with $(X^4+2X^2k_0^2+k^4)^{-1}$ (k_0 is the $\bar{K}N$ c.m. momentum at the energy of the $\Lambda(1520)$ resonance), while for D_{13} we have replaced the constant scattering length approximation used in Kim's fit by a rank–zero **K**–matrix reproducing Kim's partial amplitudes around the D–wave resonance.

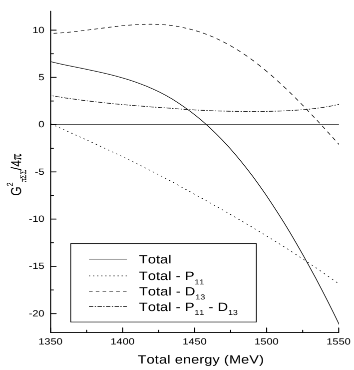

Figure 2. $G^2_{\pi\Sigma\Sigma}/4\pi$ from $\pi\Sigma \rightarrow \pi\Sigma$ and $\pi\Lambda \rightarrow \pi\Lambda$

We present here the results of this analysis (where for completeness we include also estimates of the contributions from intermediate– and high–energy regions to the dispersive integrals, which turn out however to be quitesmall) as the values for the different couplings versus the energy at which the D.R.'s are evaluated, both with and without the (small) P_{11} and D_{13} waves. For elastic πY scattering the results without the last one correspond to the old evaluations performed by Chan and Meiere [3], but only at the energy of the $\bar{K}N$ threshold. In the elastic πY scattering (figg. 1, 2) results there is an indication of large cancellations between the two waves (and therefore an essential instability for an otherwise unconstrained analysis as Kim's one). Being the coupling of the D_{13} wave to the $\pi\Sigma$ channel quite small, this cancellation does not materialise in the inelastic $\pi\Lambda \rightarrow \pi\Sigma$ channel D.R. (fig. 3), which therefore is extremely sensitive to the P_{11} contribution. This instability does not allow to determine the $G_{\pi Y\Sigma}$ coupling constants with the accuracy claimed by previous calculations [3]. If the (combined) contributions from P_{11} and D_{13} waves were much overestimated, then it would still be possible for these couplings to agree with each other and with SU(3)–symmetry predictions.

These results show that the low–energy $S = -1$ meson–baryon sector is less well known than currently believed, and that it deserves more accurate experiments and analyses if one wants to reach a level of knowledge comparable to that of the πN one [5,6,7]. DAΦNE is the right machine to achieve this goal.

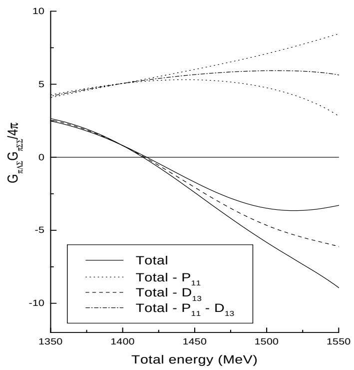

Figure 3. $G_{\pi\Lambda\Sigma}G_{\pi\Sigma\Sigma}/4\pi$ from $\pi\Lambda \to \pi\Sigma$

Also, much more stringent constraints from unitarity, analyticity and crossing symmetry than those from $\bar{K}N$ forward D.R.'s (as *e.g.* used by A.D. Martin) have to be enforced if a stable and accurate parametrization of the low–energy region has to be extracted from the data [8].

References

1. J.K. Kim, *Phys. Rev. Lett.* **19**, 1074 (1967)
2. A.D. Martin, *Nucl. Phys.* B **179**, 33 (1981)
3. C.H. Chan and F.T. Meiere, *Phys. Lett.* B **28**, 125 (1968)
4. M.L Gupta, R.A. Arndt and L.D. Roper, *Nucl. Phys.* B **37**, 173 (1972)
5. P.M. Gensini, R. Hurtado, G. Violini, πN *Newslett.* **13** (1997) 291, also available as nucl-th/9709023.
6. P.M. Gensini, R. Hurtado, G. Violini, Univ. Perugia report, April 10, 1998, presented at *"Int. Workshop on the Spectoscopy of Hypernuclei"*, Sendai January 1998, to be publ. in Genshikaku Kenkyuu, also available as nucl-th/9804024.
7. R. Hurtado, Ph.D. Thesis, Univ. di Perugia, February 1998.
8. P.M. Gensini, R. Hurtado, G. Violini, πN *Newslett.* **13** (1997) 296, also available as nucl-th/9709022.